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# Quasi-isentropic drive development for peak pressures > 10 Mbar

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October 26, 2012

American Physical Society - Division of Plasma Physics  
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# Quasi-Isentropic drive development for peak pressure $> 10$ Mbar



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**American Physical Society**

**Division of Plasma Physics**

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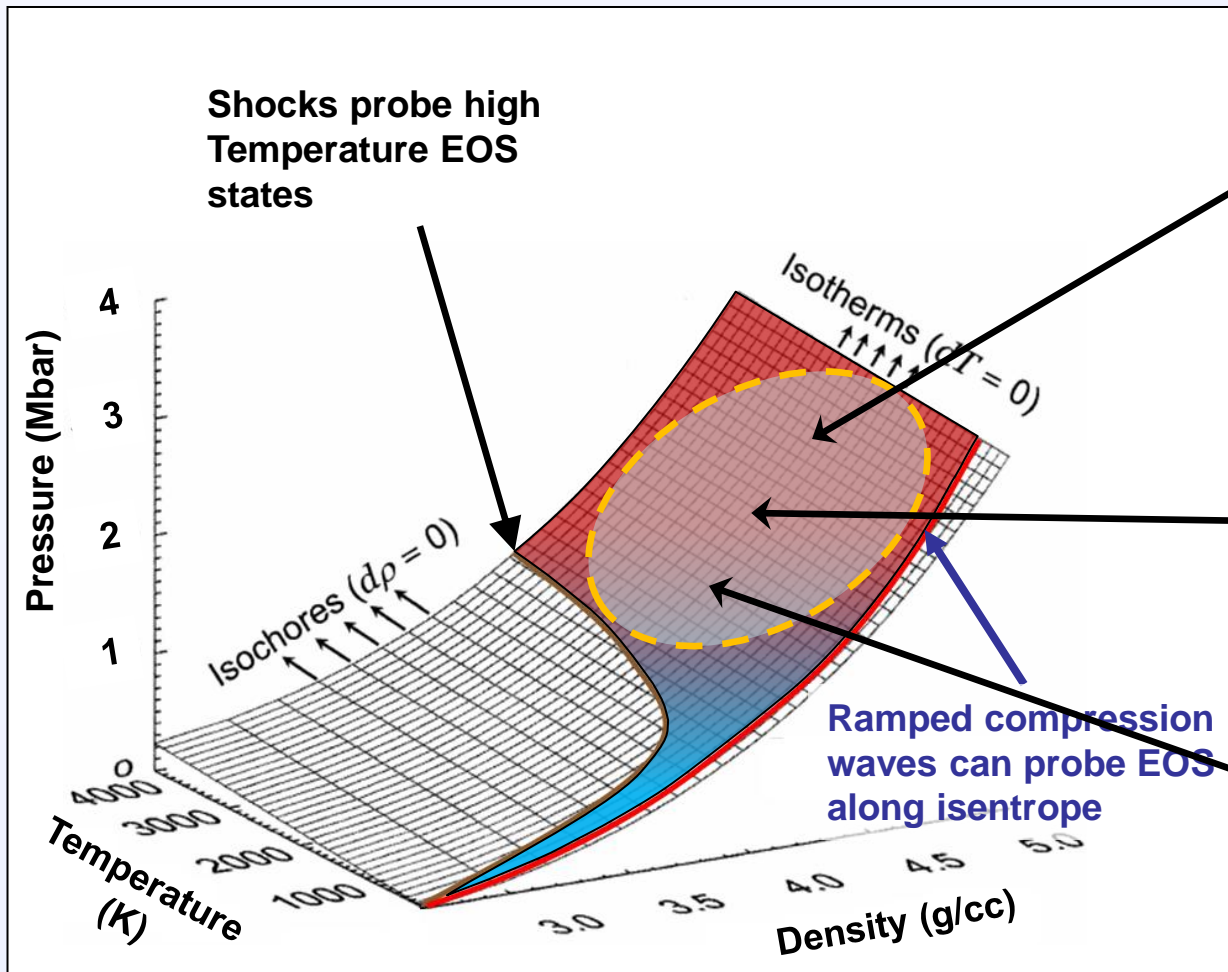
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-PRES-xxxxxx  
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# Outline

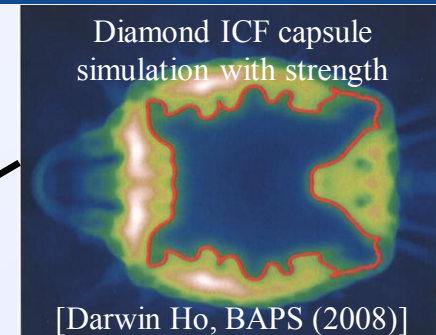
- Drive is created by the stagnation of a multicomponent, releasing reservoir (How drive is created)
- Predicted > 10 Mbar drive platform design
  - Current status of Cu and other reservoir components
  - What still needs to be done (known unknowns)
- Summary



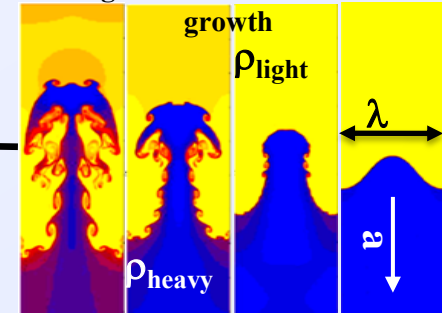
# Achieving off-Hugoniot, high-pressure measurements are important in many fields of study



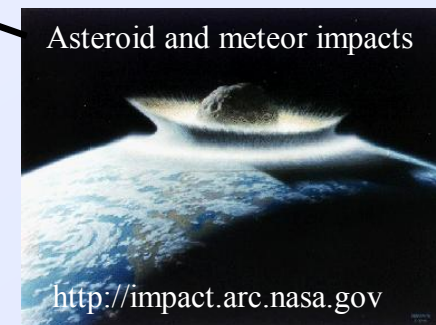
Ramp and shock compressions follow different paths on Equilibrium EOS surface (Figure courtesy of Ray Smith and Jean-Paul Davis).



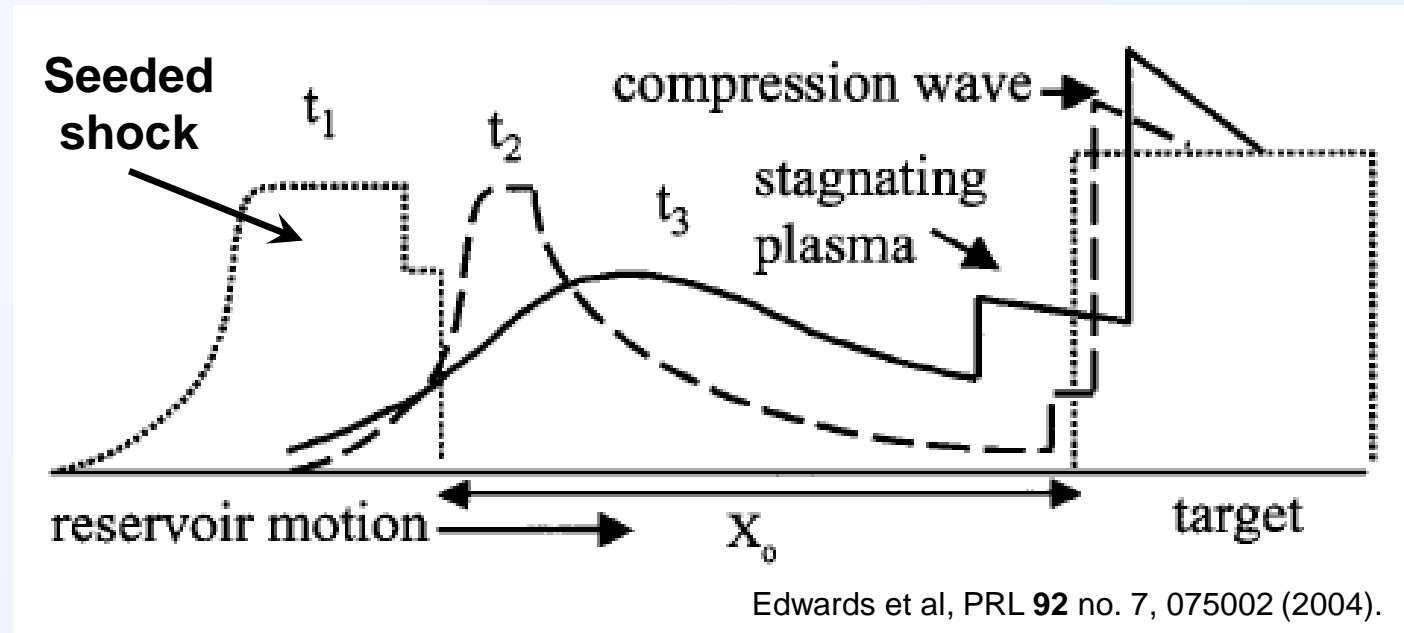
Strength measurements via RT



[H-S. Park, PRL **104**, 135504 (2010)]

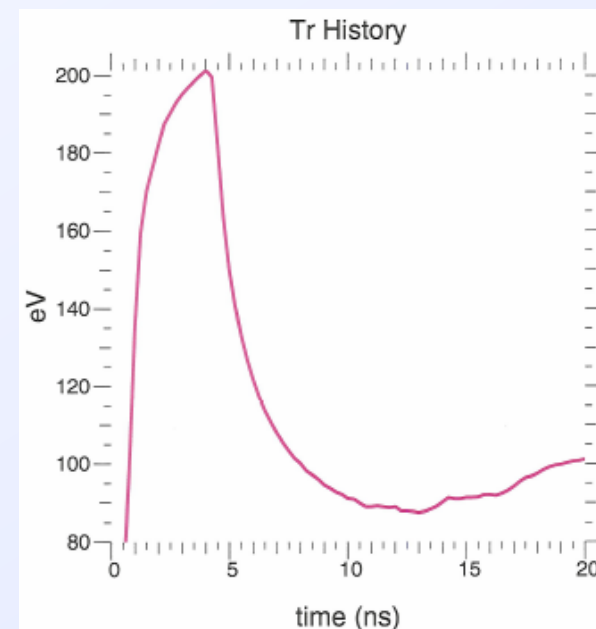
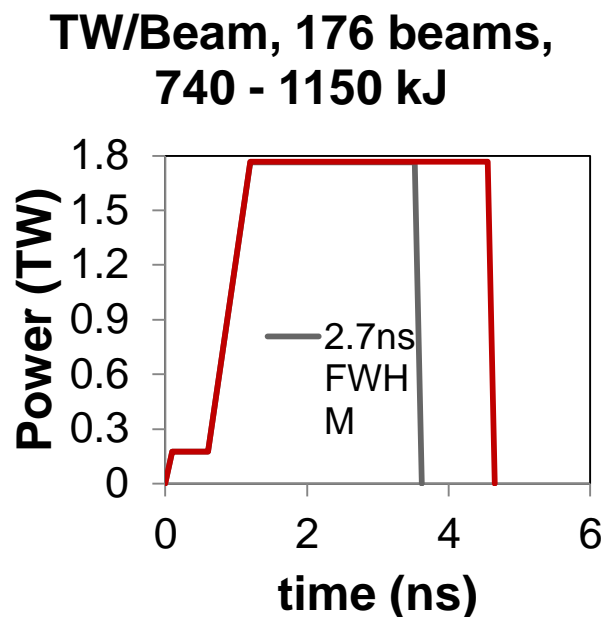
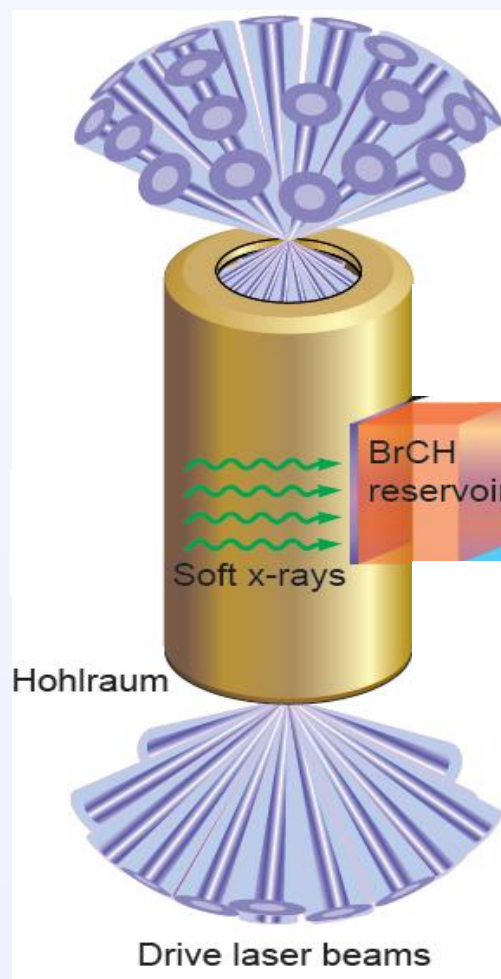


# Single material gradient density pistons work by shock release and recompression



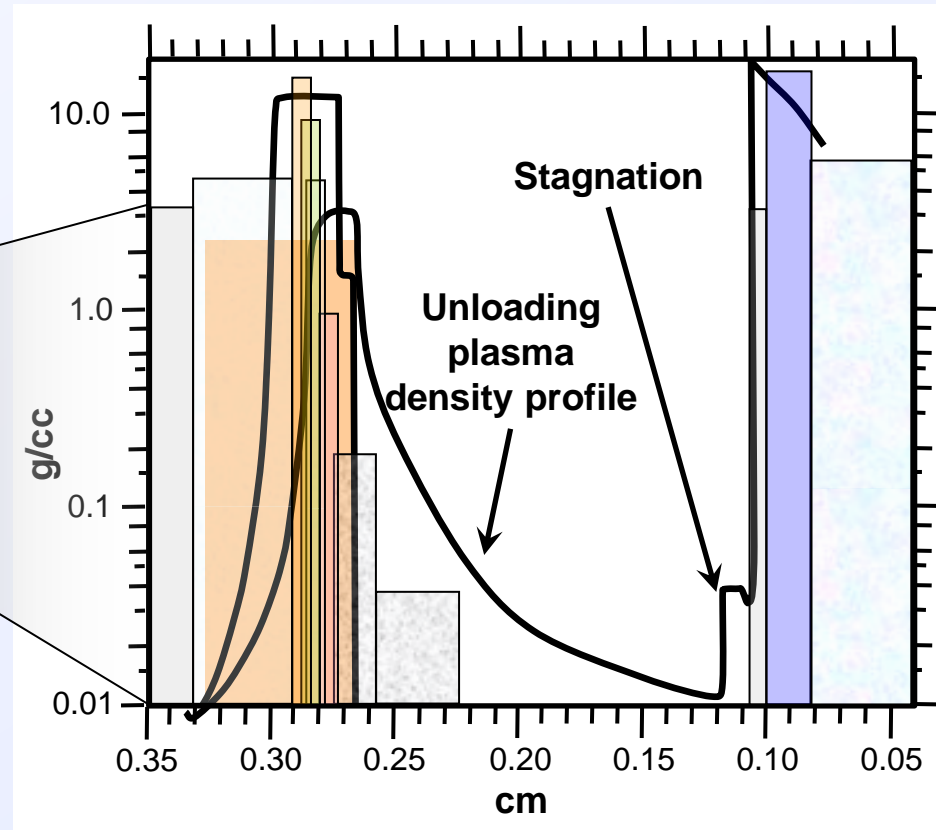
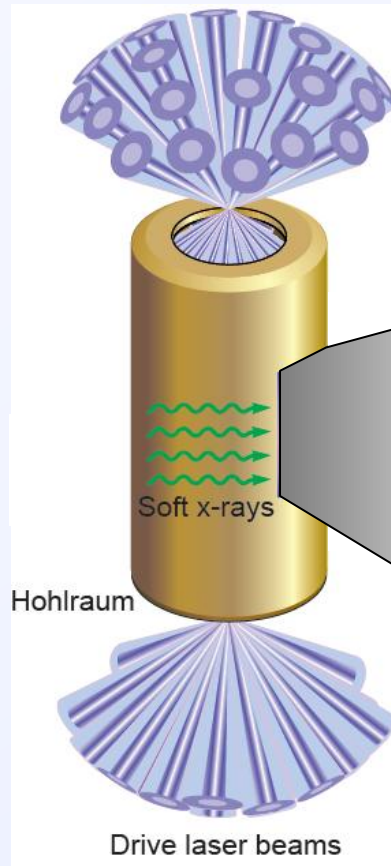
Key component is seeding a strong planar shock in a reservoir. Any platform that can seed a strong enough shock will can create a gradient density piston (Z, Omega, gas-gun, high-explosives, direct laser ablation, NIF, ...).

# Shock is seeded by laser induced ablation



- The energy in the laser beams is transferred to the reservoir via ablation.
- The integrated  $T_r$  history produced by the lasers into the hohlraum is proportional to the final pressure on the sample.

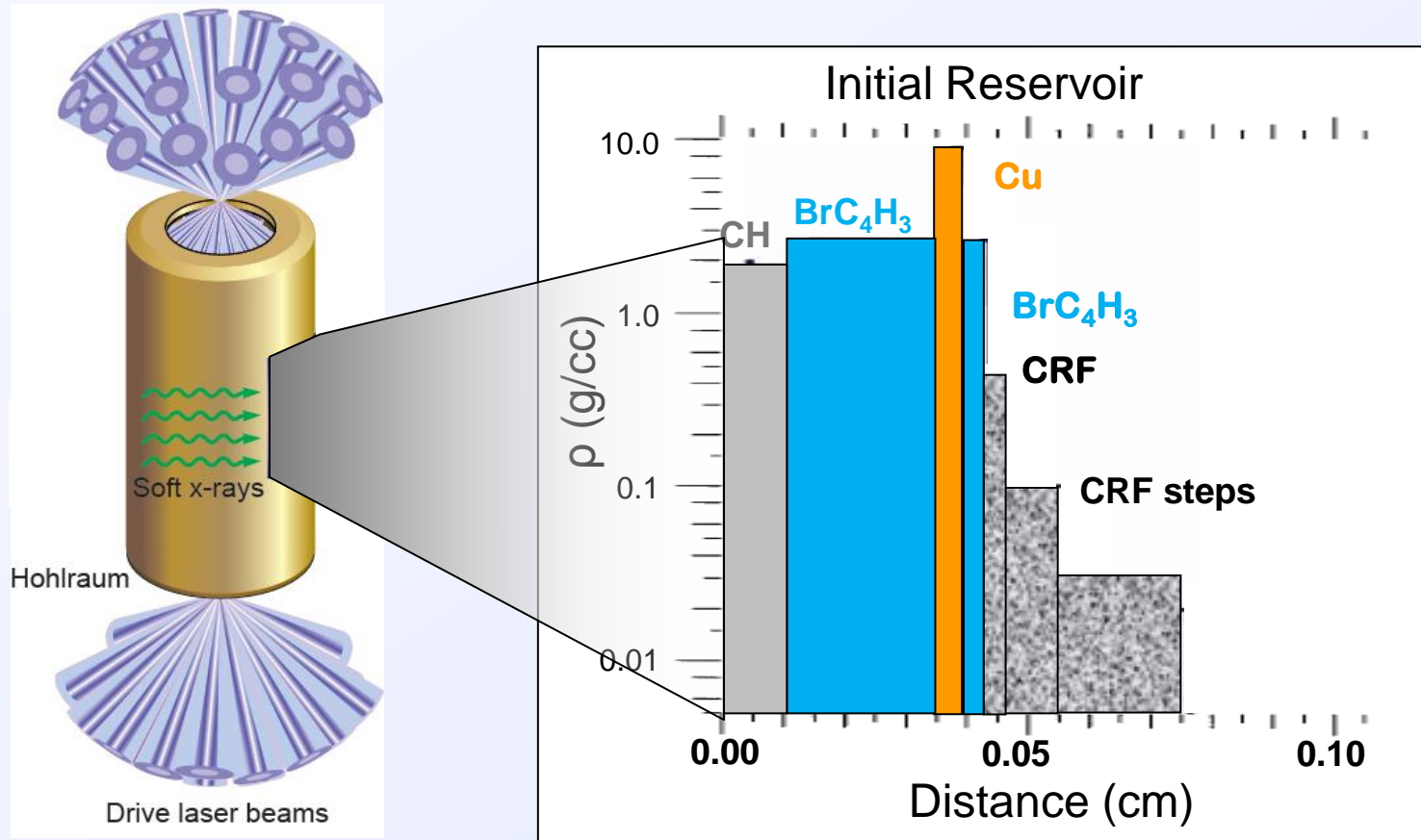
## Put in 10 Mbar drive reservoir from NIF Cu shot



Solid density layers allow for higher peak pressure ( $P_r \sim \rho \cdot u(t)^2$ ).

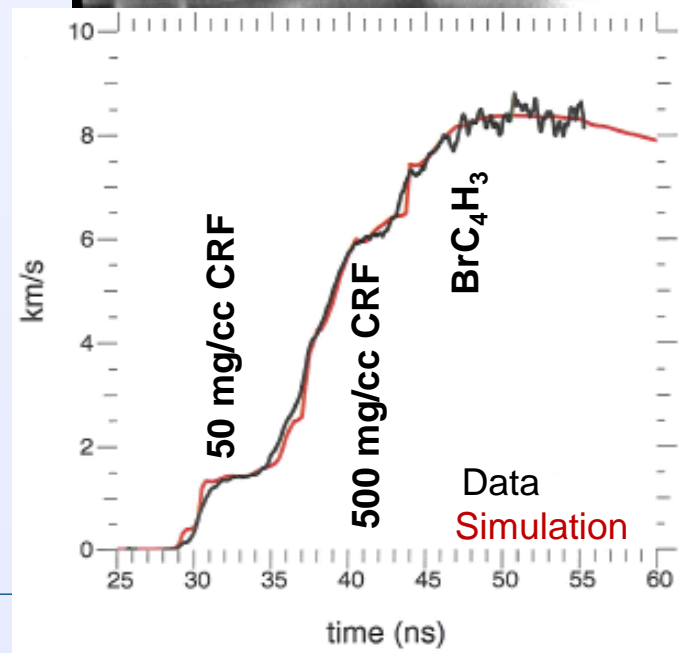
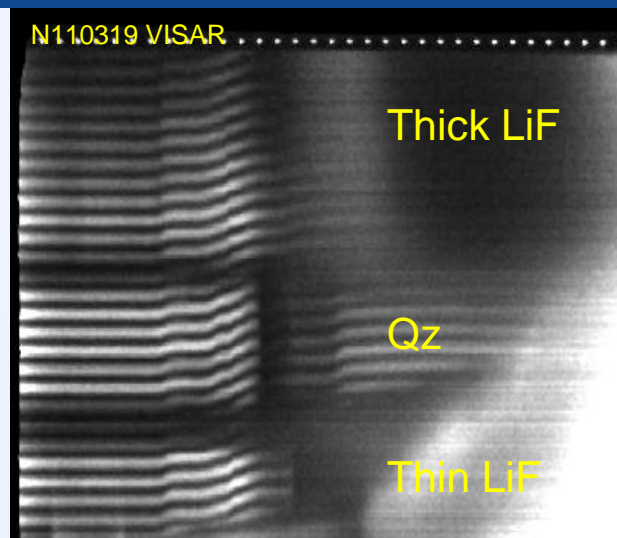
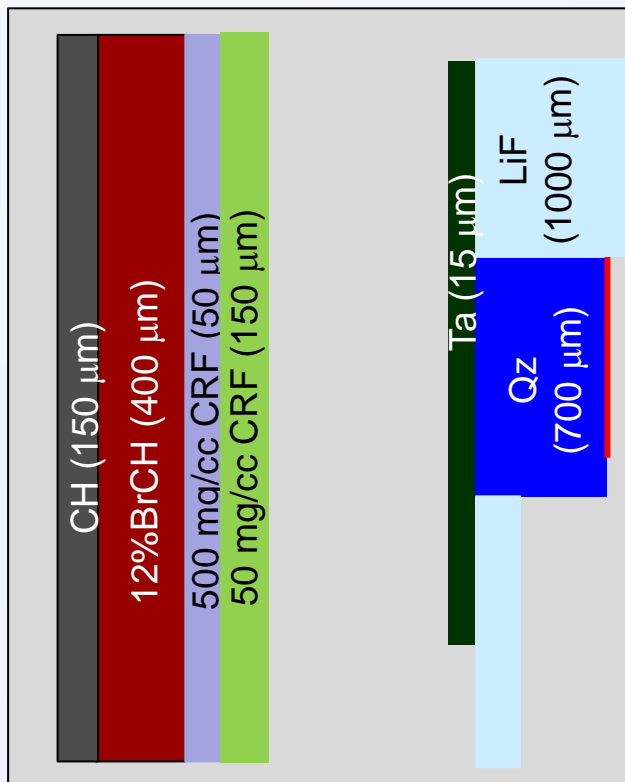
Use of foam layers shortens gap and increases peak pressure.

## Full >10 Mbar Reservoir has Cu and CRF foam steps

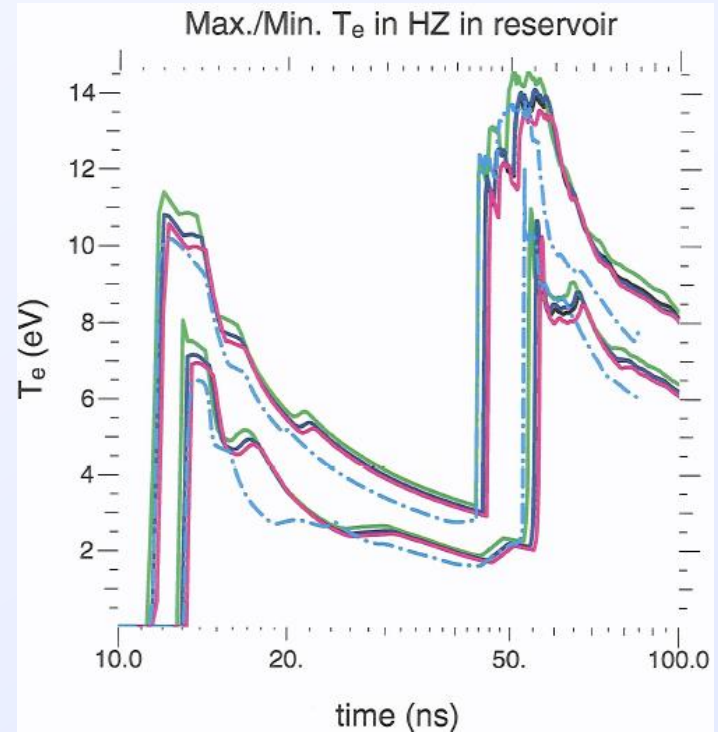
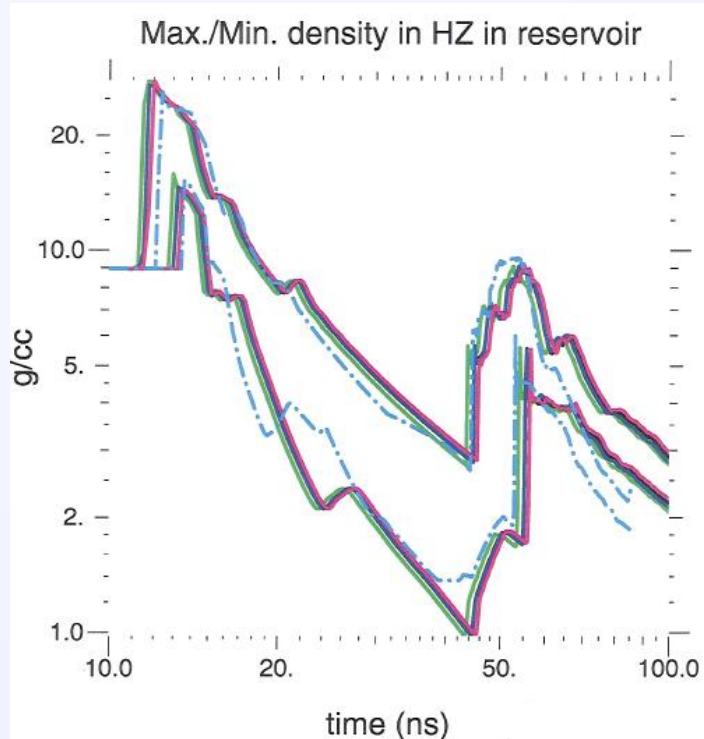


The ability to simulate the release and recompression behavior of the density steps is critical to designing a >10 Mbar quasi-isentropic drive.

# First we tested the $\text{BrC}_4\text{H}_3$ and CRF foam behavior

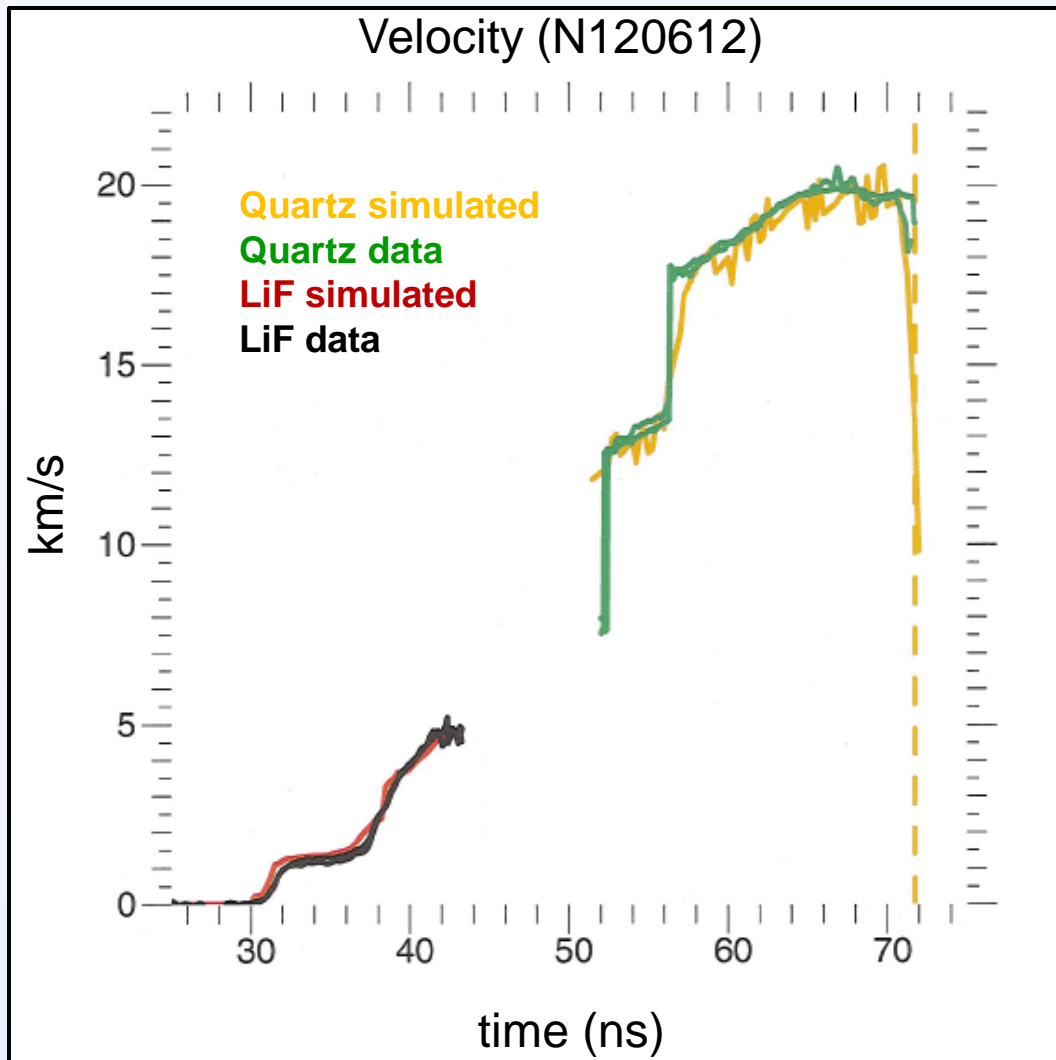


# Designed simplified Cu layer reservoir to match expected $\rho(t)$ and $T_e(t)$ of >10 Mbar design



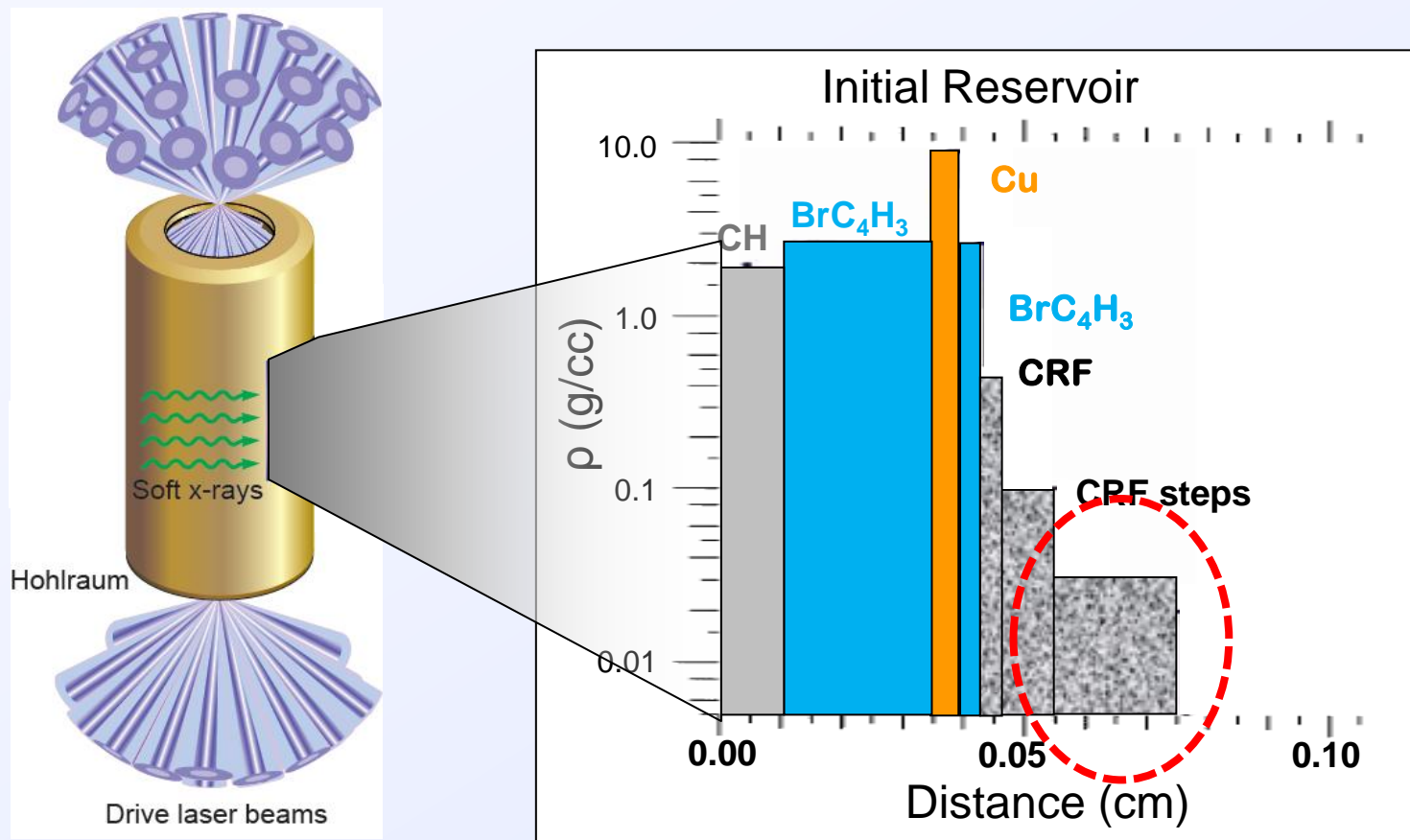
EOS region probed by simplified Cu layer reservoir is designed to measure region of interest for full >10 Mbar design.

## Cu reservoir drive behavior was as expected



- CRF and  $\text{BrC}_4\text{H}_3$  behavior behaves as expected.
- Cu release is also in agreement with predicted behavior.
- Laser coupling to reservoir is also as predicted (peak velocity matches simulation)

# Low density ( $< 50$ mg/cc) foam behavior is remaining unknown



All components of drive reservoir have been tested except for low density foams ( $< 50$  mg/cc).

## Summary

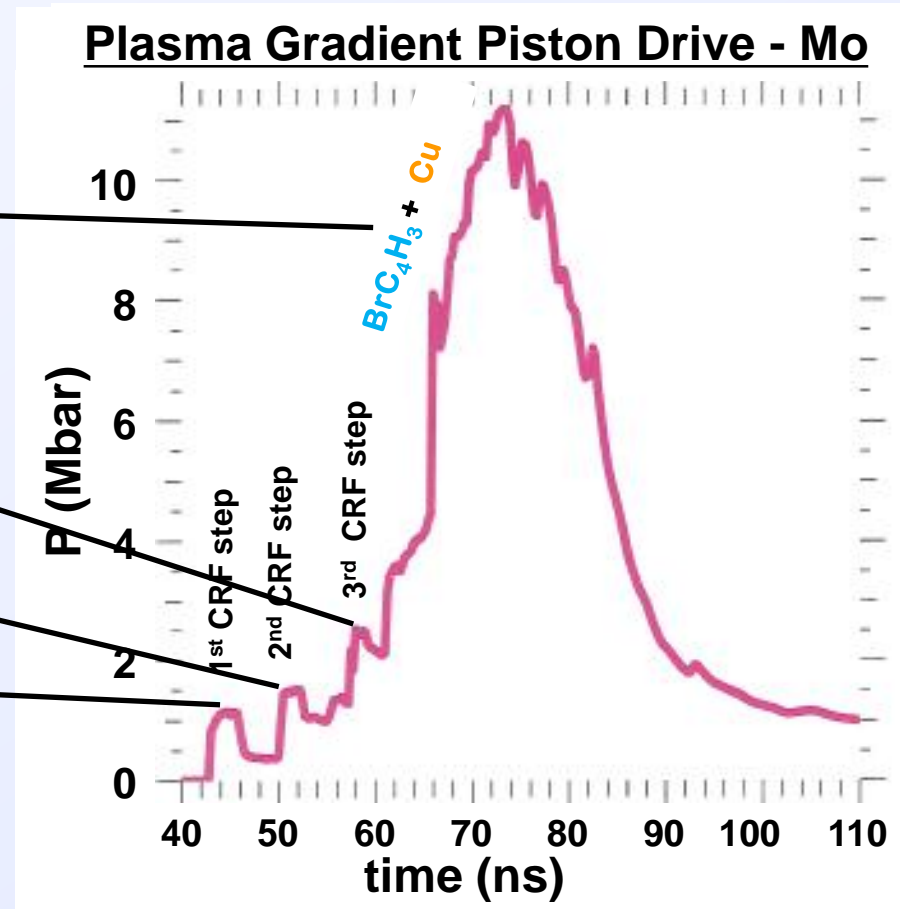
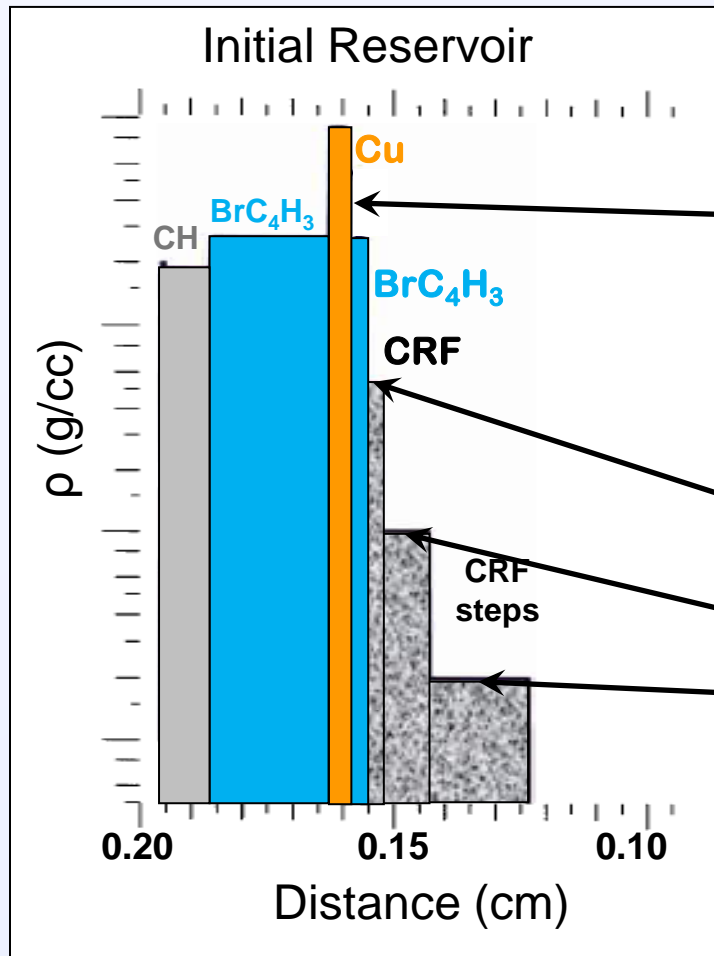
- Drive is created by the stagnation of a multicomponent, releasing reservoir.
- Tested  $\text{BrC}_4\text{H}_3$  and CRF foam (50 – 500 mg/cc) components of drive.
- Tested high density component of >10 Mbar drive reservoir and found the measurement to be in agreement with simulations.
- Release and recompression behavior of low density foams (< 50 mg/cc) needs to be quantified to complete validation of >10 Mbar drive.



# Backup slides



# A plasma gradient piston can drive Molybdenum to 10+ Mbar quasi-isentropically without inducing melt



# Observable density layers in VISAR data allow precision tuning of drive profile.

Precise tuning of the drive pulse can be achieved since the relative timing, duration, and density of each step can be independently adjusted.

